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INFORMATION ON USSR HYDROELECTRIC POWER STATIONS

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INFORMATION ON USSR HYDROELECTRIC POWER STATIONS

/Following is the translation of a series of unsigned brochures on USSR electric power stations and on the All-Union Institute for Planning Hydroelectric Stations, published by the Ministry of Construction of Electric Power Stations USSR, Moscow, 1959./

The Institute for Planning Hydroelectric Stations

On 1 January 1959 the total power of Soviet hydroelectric stations equaled approximately 11 million kilowatts. In 1958, Soviet hydroelectric stations produced approximately 46.5 billion kilowatt hours. During the seven year period 1959-1965 more than 10 million kilowatts are to be put into operation.

During the previous seven years, 1952-1958, 7.4 million kilowatts were produced in the Soviet Union.

The All-Union Institute for Planning Hydroelectric Stations (GIDEP), which was organized in 1932, occupies a significant position in the realization of these gigantic undertakings.

The work performed by the Institute is extremely varied. The Institute formulates plans for the development of power systems; projects general plans for the use of water resources and complex use of water flows; develops plans and working drawings for hydroelectric stations and hydroelectric units of great importance to the national economy; develops substations and lines for the transmission of electric power; conducts research; carries out technical supervision; studies, analyzes, and evaluates domestic and foreign experimentation in the field; fulfills normative, methodological and experimental work; publishes results of work.

The Institute also conducts construction and repair in the field of automation and telemechanization in the hydroelectric stations and power systems.

In the course of preliminary planning, the Institute encompassed the major waterways of the USSR with working hypotheses and schemes: Volga, Dnepr, Oka, Kama, Onega, Svir, Neva, Neman, Western Dvina, Irtysh, Ob, Yenisey, Angara, Syr-Darya, Terek, Rioni, Inugri, Kura, etc. Furthermore, the Institute developed water-power plans which determined the routes of complex utilization of water resources of the various regions: the Central European area of the USSR, the Urals, Siberia, Central Asia, the North Caucasus, Transcaucasus, and others.

Several of the total figures illustrate the scope of the Institute's work: on the rivers of the USSR there have been recorded 1,870 hydroelectric stations with a total power of over 125 million kilowatts, with an average yearly production of more than 650 billion kilowatt hours; technical economic reports and plans for the use of 95 million kilowatts by 1,600 GES (gidroelektrostantsiya -- hydroelectric station) have been worked out; proposals have been made for 275 more effective GES with a total power of about 30 million kilowatts.

The Institute has also invested in the restoration of the 11 hydroelectric stations destroyed during the world war. Restoration work began shortly after the liberation of the respective regions, and was carried on according to the Institute's plans. In restoring the DNEPROGES imeni Lenin (Dneprogidroelektrostantsiya -- Dnepr Hydroelectric Station) an increase in power of 16% was achieved in the same clearance-gauges of the GES hydroaggregates and building.

A large amount of planning and research work was conducted by the Institute for the post war building of hydroelectric stations. In the last three years alone plans were formulated for 34 GES with a total power of 10.2 million kilowatts. Hydroelectric stations with total power of more than ten million kilowatts, including the largest in the world, the Bratsk and Krasnoyarsk GES, as well as the Bukhtarminsk, Kaunassk, Kremenchugsk, and others, are now being constructed withe the working drawings of the Institute.

The Plyavin'sk, Cheboksarsk, Chirkey, Ingursk, Namakhvansk, Tatevsk, Charvaksk, Shul'binsk, Sayansk, Ust'Ilimsk, Zeysk, and other large GES are in the planning stage. Planning and research has begun on the use of power from tides along the northern seacoast of the European section of the Ussr.

In its work the Institute has worked out and initiated many new decisions in planning and construction.

An example of this is the use of combined types of equipment, in particular, and the distribution of drainage openings in GES buildings. This made it possible to shorten the length of the concrete spillway dam at the Novosibirsk, Kakhovsk, Dubossarsk, and several other GES, and made the elimination of a spillway dam possible at the Irkutsk GES. At the Kamsk and then at the Kayrak-Kumsk, Iriklinsk, and Pavlovsk GES the hydro-aggregates were placed in the body of the spillway dam. This made it unnecessary to construct a special building for the hydroelectric station.

At the Kamsk GES the original construction of a multichamber two-way sluice with chamber walls made of metal grooves, recoil gates, and electric locomotive traction was realized.

Many hydroelectric stations were planned and built under difficult geological conditions, such as, for example, the Kakhovsk, Gor'kovsk, and other hydroelectric stations built on soft ground. It was originally decided to build the Kamsk GES on a layer of soluble gypsum. Hydroelectric stations have been constructed in areas of porous or crumbling rock formations. (Shaorsk and Tkibul'sk GES in the Georgian SSR, the Kakhovsk GES in the Ukrainian SSR, the Pavlovsk GES in the Urals). The possibility of using a new kind of cement partition has been demonstrated (at the Mingechaurskaya, Gyumushskaya and other GES).

The Institute for Planning Hydroelectric Stations conducts its research with the cooperation of other related scientific research institutes as well as in its own laboratories.

The basic aim of the Institute's engineering technical activity for the immediate future is the lowering of cost, the acceleration of power lead in, and improvement in the construction of hydroelectric stations.

Most important for attaining these goals is maximum application in hydrotechnical installations of composite reinforced concrete and concrete elements, of thin walled reinforced concrete pre-tested constructions, and the use of arched dams.

A characteristic of hydroelectric station construction in the USSR is its complexity.

These construction projects, as a rule, are not concerned solely with solving power problems, but with solving problems of irrigation, water transport, floods, etc., as well. For example, all the hydroelectric stations in Central Asia besides producing electric power

provide for the irrigation of hundreds of thousands of hectares of arid and desert land. After the completion of the cascades on the Volga and Lower Dnepr these rivers have become deep transport routes. Along with this, great possibilities arise for carrying out major irrigation projects in the needy regions of the Volga and southern Ukraine.

Research work is conducted by complex expeditions composed of hundreds of groups and detachments of the Institute. Yearly, tens of thousands of linear meters of boreholes are covered, more than 1,000 hydrometic stations which measure the level of water and the amount used are in operation.

The Institute's researchers develop methods for varied studies of natural conditions, which make it possible to slove the most complex technical problems. New types of research equipment are developed and put to use on geological and hydrogeological projects as well as in the laboratory.

The Institute also conducts planning and research for foreign governments.

In the KNR (Chinese People's Republic) a hydroelectric station project has been undertaken at San-menhsia, and a scheme has been worked out for the complex use of the Yellow River.

Specialists of the Institute are participating in the formulation of a plan for the complex use of one of the largest rivers in the world, the Yang-tse. These specialists are also participating in the planning of the Sen-hsia GES (more than 20 million kilowatts power), and several other hydroelectric stations. In cooperation with specialists of KNR plans are being formulated for the use of border areas of the Amur and Argun' rivers.

The Institute is carrying on hydroelectric station planning projects for other socialist countries, and for Afghanistan as well.

GIDEP, together with Norwegian and Afghan organizations, is conducting planning and research on joint use of bordering rivers. The Institute sends its specialists to a number of countries for the purpose of consultation and rendering technical assistance.

The Institute for Planning Hydroelectric Stations has seven territorial departments which carry out a whole complex of planning and research projects: Moscow, Leningrad, Tiflis, Central Asia, Ukraine, Bakinsk, Armenia, and one specialized in Moscow -- the OATN -- (Otdelenie avtomatiki, telemekhaniki i naladki -- De-

partment of Automation, Telemechanics and Repairs). In the capitals of union republics - Stalinabad, Frunze, Alma-Ata, and Minsk -- there are permanent planning and research groups.

Of great significance for the operational accomodation of construction are the Institute's planning groups at the building sites. The Planning groups also take charge of supervision of the building project.

At the present time there are more than 5,000 technical and engineer workers in the employment of the Institute.

The Institute's largest departments are at Moscow and Leningrad.

The Moscow Department has formulated hydropower plans for use of the rivers Angara, Western Dvina, Neman, and is completing plans for use of the Selengi River. Ten hydroelectric stations with total power of approximately two million kilowatts have been built according to its plans: the Gor'kovsk on the Volga, the Irkutsk on the Angara, the Kamsk, Iriklinsk, Krasnopolyansk, Maykopsk, Belorechensk, Ordzhonikidzevsk, Sengileyevsk, and Svistukhinsk.

Construction of the Bratsk hydroelectric station on the Angara River is being carried out according to the plans of the Moscow Department of the Institute for Planning Hydroelectric Stations. This hydroelectric station has a power capacity of 3.6 million kilowatts, the Plyavin'sk GES on the Western Dvina with power of 600 thousand kilowatts, the Ust'-Ilimsk hydroelectric station on the Angara with more than three million kilowatts of power, and others.

Plans have been completed for the ship elevator of the Bratsk GES, with more than 100 meters of pressure.

The Moscow Department has carried out restoration and reconstruction of the hydroelectric unit at the Fengman Hydroelectric station on the Sunggare River in the Chinese People's Republic. This department of the Institute has also done work in the Democratic Republic of Vietnam, and elsewhere.

The Leningrad Department has made water power plans for the Northwest, Urals, Kazakhstan, the Central European Section, parts of Western Siberia, and other economic sectors. According to its plans, more than 30 GES have been constructed, with total power capacity of more than 2.8 million kilowatts. This includes the cascade of the GES on the Niva, the Verkhne-Svirsk and Ul'binsk, the Komsomol'sk and Tavaksk on the Chirchik River; the

Ust'-Kamenogorsk on the Irtysh (the largest one-chamber mining type sluice in the world -- 40 meters of pressure), the Novosibirsk on the Ob, the Narvsk, Knyazhegubsk Ondsk, and others.

The total power capacity of the GES under construction by the Leningrad Department exceeds five million kilowatts. The largest of them -- the Krasnoyarsk GES on the Yenisy -- has 14 aggregates of 300,000 kilowatts each, and a vertical mechanical ship elevator 120 meters in height. This department is also building the Bukhtarminsk GES on the Irtysh, and others.

The Leningrad Department conducts planning and research work at the Shul'binsk GES on the Irtysh, the Sayansk on the Yenisy (over three million kilowatts), the Zeysk (800,000 kilowatts), and others.

The Department has constructed two hydroelectric stations in Albania, and is currently building the Sanmenhsia GES on the Yellow River in the Chinese People's Republic.

The Tbilisi Department conducts planning and research work mainly for the G orgian SSR, whose potential hydroelectric resources reach 70 billion kilowatt hours per annum. This department mainly plans diversion and composite GES in mountanous regions with tunnel diversions, and other subterranean constructions. The department has built 16 GES with total power of over 500 thousand kilowatts with pressures up to 500 meters -- this includes the Khramsk No 1, Sukhumsk, Chitakhevsk, Gumatsk and Samgorsk, as well as the Tkibul'sk and Shaorsk, which were built in cave regions. The Khramsk GES No 2 is being built, as well as the Ladzhanursk, which has an arched dam of approximately 70 meters in height. Planning and research work is being conducted for G orgia's largest GES, the Ingursk, which has a dam 240 meters in height.

The Institute's Specialized Department of Automation, Telemechanics, and Repairs has performed, during the post war years, large planning, construction, experimental, and repair tasks in connection with the automatization of previously constructed hydroelectric stations, and has done repair work for most of the hydroelectric stations built in the Ussr.

All the new hydroelectric stations being planned now are automatic and, when necessary, capable of being operated by remote control.

At the present time all the hydroelectric stations in operation in the power system are fully automatic. Starting and stopping of the aggregates is accomplished

by a single impulse. Approximately 70% of them are equipped with remote control devices.

The Institute for Planning Hydroelectric Stations has worked out model plans for hydrotechnical constructions, as well as normative, methodological, and information materials on all the most important problems of planning, research, and building of hydroelectric stations, on problems of new technics, and mechanization of research and construction, etc.

Normative, methodological, and information materials published by the Institute consist of more than 1,500 printed pages.

The main task of the Institute for Planning Hydroelectric Stations at the present time is the security, through planning and research materials, of hydroelectric station construction for the current seven year period 1959 to 1965, and the years to follow.

The Institute's Central Asia Department plans hydroelectric stations in the territories of the Uzbek, Tadzhik, Turkmen, and Kirgiz SSR.

This department set up Central Asia's water power plan. Thirty hydroelectric stations with a total power of more than 500-thousand kilowatts have been built according to its plans, including the Farkhadsk and Kayrak-Kumsk hydroelectric stations on the Syr-Darya River, the Bozuyskiy waterfall, the Khishrausk, Varzobsk, Shaarikhansk, and other GES. At the present time the Uch-Kurgansk hydroelectric station is being built on the Naryn river, and the Golovnaya on the Vakhsha River. The Charvask GES, with a dam 160 meters high and made of local materials, is being planned on the Chirchik River.

The Central Asia Department also performs planning and research at two hydroelectric stations in Afghanistan.

The Ukrainian Department basically plans the Dnepr cascade hydroelectric stations. The operative Kakhovsk GES, and the Kremenchugsk and Dneprodzerzhinsk GES belong in this category. The Kanevsk and Kiev GES have been presented with a plan to use the lower Dnepr. The Department also does planning for hydroelectric stations on the Dnestr and other rivers of the Ukraine, as well as water supply of the Donbass.

The Baku Department has completed basic planning for the Mingechaursk GES on the river Kura, and is planning a number of GES in Azerbaizhan and Dagestan. The Varvarinsk GES on the river Kura was built according to the plans of this department.

The Armenian Department is planning hydroelectric stations for the Sevan-Razdan falls, and a

number of other GES in Armenia.

The Bratsk Hydroelectric Station

A cascade of six hydroelectric stations, with a total power of more than 10 million kilowatts and power production of more than 70 billion kilowatts per year, has been constructed on the Angara River.

The Bratsk is the largest hydroelectric station in the cascade. Its total power constitutes 3,6000 kilowatts, with a yearly production of 21.5 billion kilowatt hours. This is the most powerful hydroelectric station in the world. An increase in power to reach 4,500,000 kilowatts is predicted. The hydroelectric station is situated at the Padunsk Narrows of the Angara at the beginning of the rapids. Here both banks rise straight up to a height of 75-80 meters above the water at the point where the narrows are 800 meters wide. The banks and channel in the area of the Padunsk Narrows are composed of strong volcanic rock -- diabase.

Based on many years of observation, the annual flow of water passing through the hydro-unit reaches 92 billion cubic meters. A characteristic of the Angara's water flow is its equability. This is due to the regulating influence of Lake Baykal, a large natural reservoir.

Construction at the Bratsk hydroelectric station is carried out under severe climatic conditions. The average temperature in January is 24 degrees centigrade below zero. The frost period lasts 182 days. In autumn, before the river freezes over, powerful ice formations accumulate, and in the spring blocking of the ice occurs, which causes the level of the river to rise to a height of seven meters.

The volume of the Bratsk Reservoir is 179 billion cubic meters -- 50 billion cubic meters is considered a good sized volume.

The basic equipment of this hydroelectric unit is a dam, hydroelectric station building, distributing structures, and rail and auto transportation.

The river channel is covered with a concrete grativational dam 127 meters in height, and 840 meters in length. The dam is lightened by hollow deformation seams, 3-7 meters in width.

The length of the two concrete dams on the right and left banks is 308 meters each. The earthen dams

are 723 and 2,965 meters in length.

The spillway part of the channel dam has 11 openings of 16x6 meters with segmental locks, and ten underwater drains of 3x6 meters for subsurface flow of water in filling the reservoir.

In the GES building, which is situated on the left bank of the channel, 18 aggregates of 200,000 kilowatt power each will be set up. The radial-axial turbines with working wheels 550 centimeters in diameter will be the most powerful hydroturbines in the world.

The main scheme for the electrical units is taken as a block: generator and transformer.

The generator's voltage is 15.75 kilovolts, and when increased reaches 220 and 500 kilovolts. The booster transformers are situated between the dam and the GES building. Open distributing structures are situated on the bank.

The builders are faced with the task of finishing four million cubic meters of earth and rock excavations, 13 million cubi meters of dams and rock fill, and 5.8 million cubic meters of concrete and reinforced concrete.

The building of the basic structures is broken up into two parts. First the concrete spillway dam, the main structures of the GES, and the station part of the dam are built. At this point water will begin to flow through the left part of the Angara Channel, constrained with partitions up to 300 meters. In the second stage of the building process partitions must be constructed for closing off the excavation for the station part of the dam and the remaining section of the GES structure. At this point water will flow through temporary openings in the spillway dam.

This construction work is isolated from industrial centers. This makes it necessary to have independent means for producing construction materials and of making mechanical repairs right at the site.

Duo-console gantry jib, tower and other type cranes, as well as dump trucks which unload concrete blocks directly or through chutes were provided for laying concrete.

As of the present, parts of a future city and small settlements have been bult. Railroad lines have been constructed. A high voltage line (628 kilometers with substations) for the transmission of electric power from the Irkutsk GES has been built and is already in use. The partitions for the first stage of construction have been completed. Concrete construction has been started,

and concrete is being laid in the spillway dam. A scaffold bridge is under construction.

Construction of the Bratsk GES will bring about basic changes in the economy of Eastern Siberia. The conquest of the Angara will aid in changing the remote Siberian regions into the largest industrial center of the USSR.

The Dnepr Cascade of Hydroelectric Stations

The Dnepr, one of the largest European rivers, flows through three Soviet republics -- The russian Federation, Belorussia, and the Ukraine.

The river basin is 500,000 square kilometers. The river is 2,285 kilometers in length, and has an average annual flow of 53 billion cubic meters.

A cascade of 14 hydroelectric stations, with a total power of 3.3 million kilowatts, and an annual power output of 10.4 billion kilowatt hours has been planned to cover practically the whole length of the river, from source to mouth.

The main concentration of hydroelectric power resources (90%) is in the lower regions of the Dnepr, below the mouth of the Pripyat', which is 1,064 kilometers in length, and has an average lapse of about 100 meters.

Six hydroelectric stations have been planned for this area. Of these six the Lenin Dnepr GES and the Kakhovsk have already been built, the Kremchugsk and Dneprodzerzhinsk GES are in the process of being built, and the Kiev and Kanev hydroelectric units are still in the planning stages.

After the last two mentioned hydroelectric stations have been completed, a deep, navigable route from Kiev to the Black Sea will be formed, the drying steppes of the southern Ukraine and northern Crimea (a total area of up to 3.5 million hectares) will receive needed irrigation, and the surrounding industrial areas will be assured of an adequate water supply.

The problem of utilization of the Dnepr began receiving attention long before the October Revolution. However, at that time the Dnepr received attention mainly with a view to improving navigation conditions, especially in the area of the rapids.

The Kakhovsk GES

The Kakhovsk GES is last in the cascade. Its full pressure is 16.4 meters. Its total power is 312,000 kilowatts. Average annual power output is approximately 1.4 billion kilowatt hours.

This hydroelectric station has considerably improved power conditions for industry and agriculture in the southern Ukraine, and plays an important role in the irrigation of the large areas of drying land in the southern Ukraine and Crimea.

Geological conditions here are very complex: the valley slopes are composed of porous limestone, marls, and sand. Silt and sand are deposited in the flood plane and channel.

Included in this hydroelectric unit are: GES building, a concrete spillway dam, earthen dams, and a navigable sluice. The total length of the pressure front is 3.65 kilometers.

The river channel is closed by an earthen alluvial dam, at the base of which a thick mass of estuary and sea silt is embedded. This dam, 30 meters in height, was the first earthen dam in the history of hydrotechnical construction to be built directly on silt.

The concrete constructions are on the sand foundations of the left bank flood plane.

Inthe GES building there are six aggregates with rotary blade type turbines having working wheels of eight meters in diameter.

The turbine's suction pipes equal in length 1.54 diameters of the working wheel. This has decreased the amount of concrete and earth construction needed, has eased the conditions of water reduction, and has shortened by two or three months the building time formerly needed. However, this condition has caused a relatively small decrease in power output due to some lowering in coefficient of the turbine's effectiveness.

In the GES building bottom spillway openings have also been constructed, making it possible to shorten the length of the conrete spillway dam considerably.

One of the GES's main features is a closed distributing unit with a voltage of 154 kilovolts, situated in a four story annex to the GES building on the underwater side.

Construction of the lower part of the sluice room was accomplished by first forcing in concrete.

In building the Kakhovsk hydroelectric unit, 35 million cubic meters of earthen construction were completed, and 1.4 million cubic meters of concrete and reinforced concrete were laid.

The weight of the metal rabbets and metal construction exceeded 40,000 tons.

For the purpose of protecting a number of industries and settlements from floods, sea-walls 30 kilometers in length, pumping stations, and other equipment have been built in the area of the reservoir.

The hydroelectric station's first three aggregates were put into use in 1955, and in 1956 the remaining aggregates were initiated.

<u>The Dnepr GES imeni Lenin</u>

The Dnepr GES imeni Lenin is the first GES built on the Dnepr. It was planned by the GOELRO (Gosudarstvennaya komissiya po elektrofikatsii Rossii -- State Commission on the Electrification of Russia).

This GES was put into operation in 1932. The reservoir which it created closed off the rapids and made through traffic possible on the Dnepr. During the world war this hydroelctric station was destroyed by the facist occupation power, but it was restored during the period 1944-1949. In 1947 the Dnepr GES was again in operation.

The Dnepr GES has a total power of 650,000 kilowatts. At the present time the average annual power output is 3.1 billion kilowatt hours, and after completion of the Kremenchugsk GES it will increase to 3.6 billion kilowatt hours. The GES's maximum pressure is 38.5 meters.

Natural conditions at the site of the hydroelctric unit are very favorable. The width of the valley does not exceed one kilometer, and at the base of the constructions high quality granite gneiss occur. Also, the flood area is not great in spite of considerable pressure.

The main structures of the hydroelectric unit include: the GES building with an open distributing unit, a spillway and closed concrete dams, a navigable three lock sluice and port in the upper waters. Length of the pressure front is 1.3 kilometers.

The GES building is situated on the right bank. In it there are nine aggregates of 72,000 kilowatts each with raidal-axial turbines. At the entrance to the tur-

bine pressure lines there are rapid acting locks.

The concrete gravitational spillway dam, which is 760 meters in length and 62 meters high at the highest point, has a curvilinear representation in the plan. It consists of 47 openings of 13 meters each, which are closed by flat locks. Handling of the locks is accomplished with the aid of two trestle cranes.

In the construction of the Dnepr GES approximately 1.5 million cubic meters of earth construction, and 1.9 million cubic meters of excavations were completed. 1.2 million cubic meters of concrete and reinforced concrete were laid, and the total weight of metal constructions equaled 16,000 tons.

The Dnepr GES is the most effective member of the Dnepr cascade. Its part in the powerful united southern power system, the control of flow by the Kremenchugsk reservoir, and the support of the Kakhovsk GES make expedient the Dnepr GES's increase of power by 750,000 kilowatts, and its consequent increase to 1.4 million kilowatts.

In order to achieve this, six additional aggregates of 125,000 kilowatts each are needed, which can be placed in a separate building on the left bank.

The Dneprodzerzhinsk GES

This hydroelectric station is being constructed on the outskirts of Dneprodzerzhinsk. The nearness of thriving industry, the possibility of using local building crews, the use of living accomodations and the social institutions of the city, and the presence of electrical equipment and roads in the immediate vicity contributed to the rapid completion of the basic construction of the hydroelectric unit, and considerably shortened the time and volume of work during the preparatory period.

The hydroelectric unit includes: station building, concrete spillway dam, navigable sluice, earthen dams, and sea walls built from rocks and debris fallen from the valley slopes of the Orel' River.

The concrete structures are built on granite gneiss, and the earthen dams on sandy soil.

The GES's total power is 350,000 kilowatts. For several years its average annual power output has been 1.25 billion kilowatt hours. Its pressure is 12.4 meters. The Dneprodzerzhinsk GES will be working on the flow regulated by the Kremenchugsk GES. Its own reservoir is

capable of providing only daily control.

Eight aggregates with rotary blade turbines will be situated in the station building.

A machine room has not been included in the plans of the above water section of the GES building. The aggregates will be served by a trestle crane capable of lifting 500 tons.

The concrete spillway dam will have ten openings of 16 meters each, which are closed by double flat locks 15 meters in height.

A one chamber sluice with railway and auto crossings comprises the hydroelectric station's navigable equipment. The sluice chamber is located in the upper waters.

The alluvial earthen dams will have a total length of approximately 34 kilometers, of which 29 will comprise a protective sea wall located along the left bank of the reservoir, and which will serve as protection of the Dnepr's flood plane and Orel' River valley from inundations. The maximum height of the channel dam is 22 meters, and in the flood plane sections it is 15 meters.

The volumes of work completed at this hydroelectric unit constitute: earth -- 44 million cubic meters, excavations -- 600,000 cubic meters; upon completion there will have been laid 850,000 cub meters of concrete and reinforced concrete; the total weight of metal constructions and hoisting mechanisms equals 18,000 tons.

The Kremenchugsk GES

The Kremenchugsk hydroelectric station, which is in the process of being built, will have a total power of 625,000 kilowatts. Maximum pressure will be 16.8 meters.

This hydroelectric station's great regulating possibilities give it an especially significant place in the Dnepr cascade: The Kremenchugsk reservoir, with a full volume of 15.1 billion cubic meters, will have an effective capacity of nine billion cubic meters, which is sufficient for effecting the control of flow for a full year, and partially for several years. Also, the power and energy output of the hydroelectric stations situated lower in the cascade will be increased, and their losses due to flooding will be less. The Dnepr will become a deep transportation artery from Kanev to the Black Sea.

The Kremenchugsk GES's annual power output is approximately 1.5 billion kilowatt hours. Also, due to the regulating influence of its reservoir, the power production of the stations situated lower on the cascade has increased more than 0.5 billion kilowatt hours.

The river valley in line with the station is filled with a thick layer of quarternary sediment with a force, on the average, of 15-17 meters. On the right bank there is a stretch of dark gray granite. In places the granite covering is raised high, and even goes above the surface. Towards the south the granite reaches a considerable depth.

The hydroelectric unit's equipment includes: station building, concrete spillway dam, earthen dams, navigable one-chamber sluice. The concrete structures are built on granite, and the earthen structures are built on sand. Total length of the pressure front is approximately 12 kilometers.

The station building does not have a machine room, and the generators are situated under special cowls. The assembly area is covered, but has a collapsible roof and a sunken floor. When assembled and adjusted, the aggregates will be served by a trestle crane with a hoisting capacity of 500 tons.

There are 12 aggregates with rotary blade turbines in the GES building. The generators are three phase ionic excitation type.

Six main transformers of 180,000 kilovots each make up three blocks. Two generators are joined to each transformer.

The spillway dam is composed of ten spans of 16 meters each, which are closed by flat locks. The earthen dams are made of alluvial soil. Their total length is 10.7 kilometers.

A special feature of the navigable sluice is its lack of towers, and location of control mechanisms in abutments.

Earthen sea-walls, pumping stations, and other equipment will be installed for the protection of settlements and valuable land from floods.

The folume of basic work totals: earth -- 72 million cubic meters, excavations -- 87,000 meters, concrete -- 1.2 million cubic meters. The weight of metal constructions being assembled equals 13,800 tons.

Excavations in soft soil, and the building of earthen dams is accomplished 85% by hydromechanical means

Concrete work is done with the use of gantry jib, and ten ton tower cranes.

The Kanev and Kiev Hydroelectric Stations

The Kiev and Kanev hydroelectric units have also been planned for the lower Dnepr. These will be the top steps in this part of the cascade.

On both projects wide use of composite reinforced concrete is planned in all construction at the hydroelectric units (up to 60% of all concrete work).

The Kanev unit is also of great importance to transportation. When finished, a deep water route from Kiev to Kherson will have been completed.

The Irkutsk Hydroelectric Station

Gigantic power bases are being built in Eastern Siberia. The Angara River, which flows from Lake Baykal is the pearl of this region. It is possible to build a six station cascade here, with a total power of more than ten million kilowatts, and a power output of more than 70 billion kilowatt hours per annum. The Irkutsk GES, with 660,000 kilowatts of power, and an annual power output of 4.1 billion kilowatt hours is the first (top) step in the cascade.

Lake Baykal, an excellent natural reservoir, smooth as glass, with an area of 30,000 square kilometers, regulates the river flow, leveling it off considerably throughout the whole year. After completion of the Irkutsk GES dam the river flow became even more regular.

The Irkutsk hydroelectric station's first two aggregates were started up in December of 1956, and by 1958 the station's power had been brought up to the amount planned.

The high degree of mechanization made possible the successful course of the work. Steam shovels, having scoops of ten cubic meters in volume, and beams of 40 and 75 meters in length were used in the construction.

It should be mentioned that such machines were used for the first time under such severe climatic conditions.

Considerable amounts of earthern construction were completed: 5.7 million cubic meters of excavations, and 12.4 million cubic meters of fill. 840,000 cubic meters of concrete and reinforced concrete were laid. The weight of metal construction and equipment equalled 31,000 tons.

This building project on the Angara met with a number of difficulties. The freezing of the river goes from the lower waters up the river against the current, and is accompanied by accumulations of water under the surface of the ice, which causes sudden rises in the water level, at times reaching five meters. The continental climate is characterized by sharp changes in temperature, which reach as far as 50 degrees below zero (Centigrade) in the winter, and 35 degrees above zero in the summer.

Gravel conglomerates, and sand sediment from the present alluvium, with a force of 8-10 meters, and intermittent layers of siltstone and sandstone with streaks of coal are being laid in the channel and on the banks of the Angara. Earthquakes reach an intensity of eight points.

The pressure front of the Irkutsk hydroelectric unit is 2,740 meters long, and is made up of a station building and earthen dams made of gravel conglomerate and sandstone. The dam has an antifiltration, argillaceous core. The highest point in the channel dam is 44 meters.

Along the ridge of the dam there is an asphalt highway, and the possibility of building a railway is under consideration.

The Irkutsk hydroelectric unit has a distinguishing feature -- the lack of a spillway dam. Characteristic of the Angara is the unusual evenness in its out-flow: over a perod of 60 years of observation the greatest outflow of water exceeded the least by only 6.7 times.

Unevenness in the river's out-flow has decreased even more as a result of construction of the reservoir with a functional volume of 46 billion cubic meters, and additional regulation of water flow. This has made possible adaptation of a type of station building with spillway apparatus placed between the hydroaggregates, and has eliminated the need of a spillway dam.

The capacity of all 16 spillway openings together with the turbines provides a flow into the lower waters of more than 6,000 cubic meters per second.

The GES building is equipped with locks permitting the regulation of flood waters, repair of aggregates, etc. The locks are served by trestle cranes.

The control and measuring apparatus makes it possible...

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The aggragates are completely automatic.

Every two generators work in a block with one transformer group of 210 millivolts or an autotransformer group with a passing power of 414 millivolts. The open distributing units of 220 and 110 kilovolts are connected to the transformers by air lines. On the 110 kilovolt side a double system has been adopted -- a busbar with bypass, and on the 220 kilovolt side - a quadrangular scheme.

The Kamsk Hydroelectric Station

The Kama River is one of the largest in Europe. Its length from source to mouth is 2,030 kilometers. There are approximately 60 cities and many steelements along the Kama and its tributaries. The banks and surroundings of the river are very picturesque, and attract many tourists. The Kama basin is rich in timber, and various useful minerals.

The river's water gathering area constitutes 38% of the Volga's gathering area. Over a period of several years the Kama's average flow at its confluence with the Volga exceeds the flow of the latter somewhat, and at Stalingrad equals approximately half the Volga's flow. The Kama's total drop from source to mouth is over 100 meters.

Due to the size of its flow at the mouth (130 cubic kilometers) and at Perm (52 cubic kilometers), the Kama possesses great stores of hydroenergy. These stores of hydroenergy reach up to as much as 12 billion kilowatt hours.

The Kama hydroelectric station at Perm is the first on the Kama River.

Its total power has been calculated at 504,000 kilowatts. Its average power output over a period of

several years before the building of reservoirs in the headwaters was calculated at 1,835 million kilowatt hours.

The Kama hydroelectric station dam's support reaches up the river more than 300 kilometers.

In places the reservoir is 25-30 kilometers wide.

The geological formations are very complex in the Kamsk hydroelectric station construction region, and have considerably complicated the planning of constructions which will ensure the safety and permanence of the equipment.

Never before in the history of hydrotechnical building have like examples of supporting structures been encountered under such pressures, and in similar circumstances. The large gypsum content of the bedrock is one feature of the complex geological formations in the building area of the Kama hydroelectric unit.

At a depth of 50 - 55 meters bedrock joins a layer of gypsum of up to 10 meters tension, and then a layer of dry gypsum or anhydrite of very great tension.

The upper layer of bedrock, which is almost devoid of gypsum, was chosen as a foundation for building.

The top of this layer was covered with a waterproof facing. First an antifiltration screen was constructed of several rows of chinks, into which a cement solution, stable against sulfur compounds, was pressed. Also, at some distance from the beginning of the facing a drainage screen was provided, which served to carry off filtration into the lower waters.

For the purpose of protecting the construction from lateral filtration, the cementation and drainage screens were also extended in the direction of the bank, and under the earthen dam.

The Kama hydroelectric station has neither a separate GES building, nor a spillway dam, such as are usually found at hydroelectric stations. All the Kama GES aggregates are situated within the body of a reinforced concrete spillway dam.

Thus, a new type of construction was created -- a spillway hydroelectric station.

This was the first hydroelectric station of its kind in the world.

The Kama GES does not have a whole room devoted to machinery like most hydroelectric stations. Each aggregate is situated in its own spillway span. On the spillway ridge, metal covers are constructed in

each span for mounting and dismounting the aggregates.

In the body of the spillway there is a two story building in which auxiliary equipment is housed. When the flood waters are let out, the station finds itself temporarily under water.

All the GES's production communications, which connect it with work units and various other activities, are situated on supports on the lower side of the channel in a two story structure above the spillway. There are 23 vertical aggregates and one horizontal aggregate in this hydroelectric station.

The structure of the vertical aggregate differs in that its base is mounted on the turbine cover. This decreases its height considerably.

The horizontal aggregate is the first in the world of like construction and power. Water is brought to the turbine from two sides through pipes which circle the hydrogenerator chamber. The horizontal aggregate generates the same power as a vertical one with a smaller wheel, and has an optimum kpd (koefitsient poleznogo deystviya -- efficiency)of 0.5% higher than the vertical aggregate.

Three trestle cranes provide for the mounting and repair of the station's aggregates, the turbine locks, and spillway pipes. Three jib cranes with a hoisting capacity of 20 tons provide for the cleaning of the nets. One trestle crane serves the suction pipe repair locks.

The type of construction described here has considerably decreased the total volume of the various basic construction jobs.

Increase in the number of aggregates has made it possible to build a comparatively shallow foundation on the upper, non-gypsum layer of bedrock.

Decrease in the depth of the foundation and volume of concrete work needed has shortened construction time considerably. This shortening of construction time more than compensates for the small decrease of the aggregates' power coefficient.

This station's electrotechnical aspect is also carried out in an unusual manner.

In order not to increase the number of transformers and high tension equipment, every six hydrogenerators are joined to a transformer group consisting of three one-phase transformers of 150 megavolts.

In order to decrease short-circuit currents, the winding of the transformers' generator tension is divided into two parts; three generators are joined to each of them.

All starting, stopping, and control is carried out automatically without any intervention of personnel. A special automatic mechanism controls all the working aggregates simultaneously.

The housing of the spillway and aggregates in one structure makes possible an ejection effect during the spring high waters, when pressure at most hydroelectric stations falls considerably.

The ejection effect of water forced through the spillway makes it possible to increase power by 40% in the spring.

The maximum flow of water on the apron reaches 61.5 cubic meters per second.

The Kama is a very lively water way, and the largest timber floating river in the European part of the USSR.

For the passing of ships and rafts a multichamber sluice was built at the Kama hydroelectric unit. This was the first multichamber sluice to have electric towing power, eliminating the need for having tug boats which would have to go back up the sluice after releasing their tow.

The sluice is two-lane. It has six chambers in each lane.

The chambers are closed by recoil gates. The chamber walls are made of steel rabbets, and the heads are of reinforced concrete. The sluice is automatically controlled.

This type of sluice has a great passing capacity. When passing ships and rafts, the sluice is capable of accommodating three rafts orthree caravans in each lane.

Besides spillway and sluice, the Kama hydroelectric unit also has earthen dams: a channel dam, and a flood plane dam on the left bank.

The dams are filled with alluvium, and have a flattened profile, since they are built on soft soil.

In construction of the Kama hydroelectric unit 5.6 million cubic meters of earth excavation, 520,000 cubic meters of rock excavation, and 14 million cubic meters of concrete and reinforced concrete were laid. The weight of metal rabbets, and metal construction equalled 70,000 tons.

LIST OF PHOTOGRAPHS AND SKETCHES
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Part I.

Part II.

Part III.

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